UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

CHAIRMAN

January 16, 1998

The Honorable Edward J. Markey
U.S. House of Representatives
Washington, D.C. 20515-2107

Dear Congressman Markey:

On June 5, 1997, I provided you with an interim response to your letter of May 8, 1997, regarding safety concerns about the use of room-temperature vulcanizing (RTV) silicone foam penetration seals in nuclear power plants and the U.S. Nuclear Regulatory Commission (NRC) staff's efforts to address these concerns. As I promised in my June 5 letter, the staff has completed a response to your inquiry. This response is enclosed.

On the basis of its reviews, evaluations, and inspections, the NRC staff has concluded that RTV silicone foam penetration seals, like other types of penetration seals installed in U.S. nuclear power plants, provide reasonable assurance that a fire will be confined to the area of origin and thereby help maintain public health and safety. In addition, the multiple layers of fire protection provided at each reactor (defense in depth) offer reasonable assurance that penetration seal deficiencies, if any, will not result in actual safety consequences (for example, loss of safety systems, radiation overexposures, or offsite releases).

The staff recently assessed information on penetration seals reported by licensees and documented in NRC inspection reports. The results of this assessment, which considered information that the staff had not included in the evaluation documented in NUREG-1552, "Fire Barrier Penetration Seals in Nuclear Power Plants," reinforced the staff's previous conclusion that RTV silicone foam penetration seals are acceptable for use in nuclear power plants. The assessment will be documented and a copy of it will be forwarded to your office for your information.

The information you requested concerning the staff handling of an allegation related to RTV silicone foam penetration seals is being provided to you under separate cover.

I trust this letter resolves your questions about RTV silicone foam. If you have any further questions about the individual responses to your inquiries, or about any of the enclosed information, please do not hesitate to contact me.

Sincerely,

Shirley Ann Jackson

Shirley Ann Jackson

Enclosure: As stated

Combustibility of RTV Silicone Foam Penetration Seals

QUESTION 1. What steps is the NRC taking to ensure removal, replacement or backfitting of RTV silicone foam penetration seals to alleviate the potential risks associated with the presence of this substance in the U.S. nuclear generating stations? If no steps are being taken, please justify.

ANSWER.

On the basis of its reviews, evaluations, and inspections, such as those documented in NUREG-1552, "Fire Barrier Penetration Seals in Nuclear Power Plants," the U.S. Nuclear Regulatory Commission (NRC) staff has concluded that properly designed and installed RTV silicone foam penetration seals will provide reasonable assurance that a nuclear power plant fire will be confined to the area of origin and thereby help maintain public health and safety and will provide fire resistance equivalent to the barriers in which they are installed. Therefore, the NRC is not taking steps to have RTV silicone foam penetration seals removed from nuclear power plants.

The NRC staff inspects licensee fire barrier penetration seal programs during fire protection program and fire protection functional inspections to ensure that the licensees properly test, install, and monitor penetration seals. The staff recently completed a best effort search for NRC inspections of penetration seal programs. The staff found that between 1991 and 1997, it had conducted 105 inspections that involved installed penetration seals and penetration seal programs at 77 plants. The scope of the inspections varied from plant to plant and ranged from narrow to broad. The inspectors reviewed the adequacy of penetration seal installations, qualification, and surveillances. They also followed up on issues reported in licensee event reports (LERs) and weaknesses noted during previous NRC inspections. In some cases, the inspectors reviewed the 100 percent penetration seal reevaluation programs performed by the licensees. In other cases, the inspectors walked down the seal installations to assess their adequacy. In general, the inspectors found that the penetration seal programs were comprehensive, timely, and acceptable. In some cases, the inspectors found deficiencies and issued notices of violations. The staff will include a detailed summary of the inspections in its planned update of NUREG-1552.

ENCLOSURE

Combustibility of RTV Silicone Foam Penetration Seals

QUESTION 2a. Please provide copies of the ASTM E-136 combustibility tests that the NRC refers to in its July 1, 1996 SECY-96-146.

ANSWER.

The referenced test is Dow Corning Corporation, "Flammability Characteristics of a New Silicone RTV Foam," Kathy M. Kelly, Society of Plastics Engineers, Progress in Plastics through Education, 34th Annual Technical Conference, April 26–29, 1976, Atlantic City, New Jersey. This report is included as Appendix A.

Combustibility of RTV Silicone Foam Penetration Seals

QUESTION 2b. What is the NRC's definition of a "generic" problem and a "plant-specific" problem?

ANSWER.

A plant-specific problem is a problem that affects or exists at one plant. A generic problem is a problem that affects more than one plant, usually a group or class of plants. A generic problem could affect all plants.

Combustibility of RTV Silicone Foam Penetration Seals

"In spite of the finding that RTV silicone foam is classified as a combustible material, the report concludes that NRC staff 'found neither plant-specific problems nor generic problems of safety significance.' Section 5.4 of the technical report (NUREG-1552) detail's the staff's review of fire penetration seal programs at several reactors. In 1987, the Wolf Creek Generating Station reported that it had to repair or upgrade approximately 85% of their 1400 fire barrier penetrations. In April 1997, the Maine Yankee nuclear power station determined that 90% of its 2600 penetration seals were defective as a result of installation problems."

QUESTION 2c. Why wouldn't the aforementioned examples constitute evidence of a generic or plant specific problem?

ANSWER.

There is no relationship between the combustibility of silicone foam and the installation problems at Wolf Creek Generating Station and Maine Yankee. In addition, the key to the quote from NUREG-1552 is the staff's position that the problems with penetrations were not of safety significance (emphasis added). Since the Browns Ferry Nuclear Plant fire of March 1975, all licensees have made significant improvements in their fire protection programs. These improvements, especially the adoption of the defense in depth concept as applied to fire protection, have reduced both the probability and the potential adverse consequences of nuclear power plant fires. Using documented industry operating experience, the staff evaluated issues associated with fire barrier penetration seals. The staff also considered the potential safety significance of potential penetration seal deficiencies. On the basis of the totality of the information it found and considered, it is the staff's judgement that, overall, potential fire barrier penetration seal deficiencies do not constitute a safety issue. Typical penetration seal deficiencies do not necessarily equate to a lack of adequate protection or result in undue risk to public health and safety. The staff will include a detailed discussion of safety significance and risk significance of fire barrier penetration seal deficiencies in its update of NUREG-1552.

Nevertheless, upon contemporaneous review of the problems found at Wolf Creek, the staff concluded that they could have generic implications and, in response, issued Information Notice (IN) 88-56, "Potential Problems With Silicone Foam Fire Barrier Penetration Seals." As documented in NUREG-1552, the staff has found that this generic action, and others it has taken to address potential penetration seal problems (IN 88-04, Supplement 1 to IN 88-04, and IN 94-28) increased industry awareness of penetration seal problems and resulted in more thorough surveillances, maintenance, and corrective actions. Finally, the staff agrees that the problems found at Maine Yankee in 1997 are indicative of plant-specific problems. As documented in IN 97-70, "Potential Problems with Fire Barrier Penetration Seals,"

September 19, 1997, the problems resulted from inadequate quality assurance and quality control procedures during the original installation of the seals and because the licensee's surveillance and inspection procedures did not cover all important penetration seal attributes.

Combustibility of RTV Silicone Foam Penetration Seals

QUESTION 3a. Given the high percentage of fire barrier penetrations seals that were found to be defective at the Wolf Creek, Vermont Yankee and Maine Yankee reactors, would you agree that i) the assumption that the fire barrier penetration seals will prevent fire from spreading from one plant area to the other is invalid and ii) that the 7-50% core damage frequency estimate is an underestimate? If not, why not?

ANSWER.

i) No. It is the staff's judgment that the assumption that penetration seals will prevent fire propagation is valid. The basis for this conclusion is addressed below.

A penetration seal's fire resistance rating, which is a measure of the extent to which the seal resists the effects of fire, is determined by exposing a full-scale mockup of the penetration seal assembly to an intense standard test fire for a required period. Most nuclear power plant fire barrier penetration seals have a fire resistance rating of 1, 2, or 3 hours. The ability of a penetration seal to prevent a fire from spreading from one plant area to another depends on many factors, such as the location, size, and type of seal; the configuration and location of combustible materials and other fire hazards, if any, in the areas; and the potential for fire growth in the areas. In some cases the identified deficiencies would not affect the seals' fire resistance rating.

Licensees rely on a defense-in-depth concept that incorporates multiple fire safety measures. For example, automatic fire detection and suppression systems are provided in most areas that have safe shutdown equipment, trained fire brigades are required 24 hours a day at all plants, all areas that have safe shutdown equipment have manual fire suppression features, and combustible materials that can fuel a fire and ignition sources to start a fire are controlled. In order to adversely affect the safe shutdown capability each echelon of fire protection defense-in-depth measures would have to either fail or be significantly compromised. Considered in total, these measures provide an adequate level of fire protection at the plants and ensure that operation can be conducted without an undue risk to the health and safety of the public. Therefore, it is the staff's judgment that the safety significance of penetration seal deficiencies is low for the following reasons: (1) the deficiencies may reduce the fire resistance of the seal, but they do not necessarily render it incapable of preventing fire propagation, and (2) the defense-in-depth concept ensures that multiple fire safety measures are incorporated into the plant design.

ii) No. The calculated core damage frequency due to fires, and the contribution of fire risk to a plant's total core damage frequency, is a plant specific determination that is dependent on the plant configuration and the methodology and assumptions that are used for the analysis. The application of the calculated core damage frequency to assess the fire risk of one plant versus the fire risk at another plant is not appropriate.

The postulated fire scenarios that are the major contributors to core damage for most plants result from fires where the redundant divisions of post-fire safe shutdown components and systems are located in the same fire area. In these scenarios, fire barrier penetration seals are not considered (not modeled) in the assessment due to the fact that the factors mentioned previously have a greater effect on core damage frequency.

Scenarios involving propagation of fire from one plant fire area to another and evolving to core damage are of low frequency. This is a result of the multiple defense-in-depth measures provided such as administrative controls on combustible materials and hot work, automatic fire detection, automatic fire suppression, and intervention by the plant fire brigade. On the basis of reviews of fire risk assessments completed thus far, penetration seals have not been relied upon for the prevention of core damage. It is the staff's judgment that failure of the fire barrier penetration seals would not significantly impact the overall contribution of fire risk to the plant's total calculated core damage frequency.

Combustibility of RTV Silicone Foam Penetration Seals

QUESTION 3b. What is the core damage frequency estimate if it is not assumed that as much as 90% of the fire barrier penetration seals will prevent fire from spreading from one plant area to the other?

ANSWER.

The calculated core damage frequency due to fires, and the contribution of fire risk to a plant's total core damage frequency, is a plant specific determination that is dependent on the plant configuration and the methodology and assumptions that are used for the analysis. The application of the calculated core damage frequency to assess the fire risk of one plant versus the fire risk at another plant is not appropriate.

The postulated fire scenarios that are the major contributors to core damage for most plants result from fires where the redundant divisions of post-fire safe shutdown components and systems are located in the same fire area. In these scenarios, fire barrier penetration seals are not considered (not modeled) in the assessment due to the fact that the factors mentioned previously have a greater effect on core damage frequency.

Scenarios involving propagation of fire from one plant fire area to another and evolving to core damage are of low frequency. This is a result of the multiple defense-in-depth measures provided such as administrative controls on combustible materials and hot work, automatic fire detection, automatic fire suppression, and intervention by the plant fire brigade. On the basis of reviews of fire risk assessments completed thus far, penetration seals have not been relied upon for the prevention of core damage. It is the staff's judgment that failure of the fire barrier penetration seals would not significantly impact the overall contribution of fire risk to the plant's total calculated core damage frequency.

Combustibility of RTV Silicone Foam Penetration Seals

QUESTION 4. Page 2 of the Executive Summary states that fire barrier penetration seals are "universally accepted building components." Why did the NRC fail to mention that combustible silicone foam penetration seals are forbidden in German nuclear power plants for safety reasons?

ANSWER.

The purpose of the statement was to indicate that penetration seals themselves are not unique to nuclear power plants. The statement was not made in the context of specific seal types or materials. The scope of the staff's assessment of penetration seals did not include penetration seal materials used in foreign countries. Nevertheless, should silicone foam penetration seals not be installed in German nuclear power plants, this does not alter the conclusions stated in SECY-96-146.

Combustibility of RTV Silicone Foam Penetration Seals

QUESTION 5. In light of the significantly high contribution by fire to the overall risk of a core melt accident and evidence of repeated chronic problems with deficient and combustible RTV silicone foam seals identified in 1979, please justify the slow approach that the NRC has taken towards resolving this fire protection issue.

ANSWER.

The postulated fire scenarios that are the major contributors to core damage for most plants result from fires where the redundant divisions of post-fire safe shutdown components and systems are located in the same fire area. In these scenarios, fire barrier penetration seals are not considered (not modeled) in the assessment. Scenarios involving propagation of fire from one plant fire area to another and evolving to core damage are of low frequency. This is a result of the multiple defense in depth measures provided such as administrative controls on combustible materials and hot work, automatic fire detection, automatic fire suppression, and intervention by the plant fire brigade. On the basis of reviews of fire risk assessments, it is the staff's judgment that failure of the fire barrier penetration seals would not change the overall contribution of fire risk to the plant's total calculated core damage frequency.

In addition, the staff has observed significant improvements in the industry fire barrier penetration seal programs since 1979. During its recent assessment of fire barrier penetration seals, as documented in NUREG-1552, the staff found neither plant-specific problems nor generic problems of safety significance. On the basis of its overall assessment, the staff concluded that the penetration seal programs in the nuclear reactor industry are satisfactory. In NUREG-1552, the staff acknowledged that plant-specific penetration seal deficiencies may occasionally be found during licensee surveillances and NRC inspections. However, the staff found that licensees know what fire barrier penetration seal problems to look for, that fire test standards are available and are followed, and that seal materials and designs qualified by standard fire endurance tests such as ASTM E-119, are available. Therefore, licensees have the means to install qualified seal configurations and to correct any problems that are found. The staff also found that the generic actions it had taken in 1988 and 1994 to address potential penetration seal problems (Information Notices [INs] 88-04 and its supplement, 88-56, and 94-28) increased industry awareness of such problems and resulted in more thorough surveillances, maintenance, and corrective actions.

The NRC's routine fire protection inspection procedures are contained in NRC Inspection Manual Inspection Procedure 64704, "Fire Protection Program." During September 1997, the staff revised these procedures to provide more specific guidance for inspecting the seals and establishing their functionality.

Combustibility of RTV Silicone Foam Penetration Seals

QUESTION 6. Why does the NRC say there is no basis for specifying a non-combustibility requirement for materials whose sole function in nuclear power plants is to act as a fire barrier? Please justify your response.

ANSWER

In NUREG-1552, the NRC staff stated that it "reviewed the record for Appendix R (including interviews with the principal author of Appendix R) and found no technical basis for including the noncombustibility criterion in Appendix R." For example, the Statement of Considerations for Appendix R (45 FR 76602), which documents the technical bases for each section of Appendix R, did not explain why the Commission specified the use of noncombustible penetration seal materials.

As part of the assessment of fire barrier penetration seals that is documented in NUREG-1552, the staff evaluated the potential fire hazards associated with silicone-based penetration seal assemblies. In summary, the staff concluded that properly designed and installed silicone-based fire barrier penetration seals are not credible fire hazards and that the ability of a particular penetration seal assembly to achieve its intended design function (i.e., to contain a fire), is the foremost design consideration. A penetration seal's fire resistance rating, which is a measure of the ability of a seal to resist the effects of fire, is determined by exposing a full-scale mockup of the penetration seal assembly to an intense test fire for a required period in accordance with an industry test standard. The severity and duration of the fire test ensure that fire-resistant seal materials are used and preclude the use of materials that present fire hazards.

The NRC staff has observed such full-scale fire endurance tests first hand, and has witnessed that RTV silicone foam penetration seals can provide the same level of fire resistance as the structural fire barriers in which they are installed. That is, the fire resistance of an RTV silicone foam penetration seal is equivalent to the fire resistance of the structural barrier. On the basis of such tests, the NRC staff has concluded that properly designed and installed RTV silicone foam seal designs can perform their intended fire protection function and thereby provide reasonable assurance that a fire will not spread from one side of the fire barrier penetration seal to the other.

Combustibility of RTV Silicone Foam Penetration Seals

QUESTION 7a. What justification or criteria did the agency rely upon to waive licensee compliance with the non-combustibility requirement for materials used in fire barrier penetration seal designs as specified in 10 CFR 50 Appendix R section III Subpart M? Please provide justification of why the NRC did not take any enforcement action.

ANSWER.

Appendix R is not a set of generic fire protection requirements applicable in their entirety to

acceptance criteria for penetration seal qualification required that the temperatures recorded on the unexposed side of the seal be below the cable insulation ignition temperature. Neither the exemption nor its supporting safety evaluation addressed the fact that the penetration seals used combustible materials.

It appears that the NRC did not take enforcement action because it did not intend for Section III.M of Appendix R to preclude the use of silicone-based fire barrier penetration seal materials in nuclear power plants. Therefore, the staff did not consider the use of such materials violations of regulatory requirements.

On the basis of its reviews of documentation to date, the staff cannot determine how the combustibility issue was addressed at Duane Arnold, Maine Yankee, and Vermont Yankee. These reviews are ongoing. The results of these reviews will be documented in the planned update to NUREG 1552.

The staff has been aware of the combustible properties of silicone foam from the time of its earliest applications in nuclear power plants. A Safety Evaluation Report (SER) written by the staff for Browns Ferry Units 1 and 2, dated March, 1976, following the March 22, 1975 fire, approved the licensee's proposed use of silicone foam as a penetration seal-fire stop.

As part of the assessment of fire barrier penetration seals that is documented in NUREG-1552, the staff evaluated the potential fire hazards associated with silicone-based penetration seal assemblies. In summary, the staff concluded that properly designed and installed silicone-based fire barrier penetration seals are not credible fire hazards and that the ability of a particular penetration seal assembly to achieve its intended design function (i.e., to contain a fire), is the foremost design consideration. A penetration seal's fire resistance rating, which is a measure of the ability of a seal to resist the effects of fire, is determined by exposing a full-scale mockup of the penetration seal assembly to an intense test fire for a required period in accordance with an industry test standard. The severity and duration of the fire test ensure that fire-resistant seal materials are used and preclude the use of materials that present fire hazards.

The staff has also reviewed the requirements of Appendix R to 10 CFR Part 50 and the guidance of the Section 9.5.1 of the SRP. The staff reviewed the record for Appendix R (including interviews with the principal author of Appendix R) and found no technical basis for including the noncombustibility criterion in Appendix R. The noncombustibility criterion is included in the SRP because the SRP simply embodied the criterion of Appendix R. The staff noted that the noncombustibility criterion is not included in BTP APCSB 9.5-1, Appendix A to BTP APCSB 9.5-1, or the industry fire endurance test standards. The NRC staff plans to eliminate the noncombustibility requirement from the rule. The ability of a particular penetration seal to achieve its intended fire resistive design function (i.e., to prevent fire spread through a penetration opening in a fire barrier wall), as determined by a standard fire endurance test conducted and controlled in accordance with an industry standard, is the foremost design consideration. In addition, because of the severity and duration of the fire exposure, the

industry standards would ensure that fire-resistant penetration seal materials are used and would preclude the qualification of materials that present fire propagation hazards. It is clear from the staff's review that NRC fire protection regulations were never intended to preclude the use of silicone-based fire barrier penetration seal materials.

The NRC staff has observed full-scale fire endurance tests first hand, and has witnessed that RTV silicone foam penetration seals can provide the same level of fire resistance as the structural fire barriers (e.g., walls, floor, ceilings) in which they are installed. That is, the fire resistance of an RTV silicone foam penetration seal is equivalent to the fire resistance of the structural barrier. On the basis of such tests, the NRC staff has concluded that properly designed and installed RTV silicone foam seal designs can perform their intended fire protection function and thereby provide reasonable assurance that this material will not allow the passage of flame through from the fire side of the fire barrier to the non-fire side.

Combustibility of RTV Silicone Foam Penetration Seals

QUESTION 7b. After learning that both Thermo-Lag fire barrier wrap systems and silicone foam material in penetration seals are highly combustible, has the NRC required the licensees to include the combustibility of the products in their combustible loading analysis? If not why not?

ANSWER.

No. The contents of fire hazards analyses are not specified in the NRC fire protection regulation. They are, however, specified in NRC fire protection guidance documents. The NRC has not promulgated a new requirement that the licensees include Thermo-Lag and silicone-based fire barrier materials in its fire hazards analyses because the existing guidance regarding such analyses is adequate and a new requirement regarding combustible materials is not justified.

In an attachment to Information Notice 95-27, "NRC Review of Nuclear Energy Institute Thermo-Lag 330-1 Combustibility Evaluation Methodology Plant Screening Guide," dated May 31, 1995, the staff stated that for "Thermo-Lag applications, licensees, if they have not already done so, should address the presence of the combustible Thermo-Lag materials in the fire hazards analyses in accordance with existing NRC fire protection guidance." The staff also expects licensees to include silicone-based materials in their fire hazards analyses in accordance with this guidance as appropriate. The licensees audit fire hazards analyses during their fire protection program inspections.

Both Thermo-Lag and silicone foam fire barriers are fire resistant, i.e., properly designed configurations have been qualified to achieve certain fire resistance ratings. There are currently no test standards which classify either material as "highly" combustible. However, both materials are classified as "combustible" when tested in accordance with ASTM E-136, "Behavior of Materials in a Vertical Tube Furnace at 750 °C," which is a pass/fail combustibility test method accepted by the NRC.

Combustibility of RTV Silicone Foam Penetration Seals

QUESTION 7c. Has the NRC conducted or reviewed calorimetric tests of the contribution from burning RTV silicone foam penetration seals involved in a nuclear power station fire? If so, please provide copies of all test reports.

ANSWER.

To the best of its knowledge, the NRC staff has not conducted or reviewed calorimetric tests of RTV silicone foam penetration seal materials.

Combustibility of RTV Silicone Foam Penetration Seals

QUESTION 7d. Other than RTV silicone foam internal thermocouple readings of the ULC test on October 1, 1996 in Canada, what data is now in the possession of the NRC that quantifies the combustibility and fire behavior of RTV silicone foam? Please provide copies.

ANSWER.

Dow Corning Corporation report, "Flammability Characteristics of a New Silicone RTV Foam," Kathy M. Kelly, Society of Plastics Engineers, Progress in Plastics through Education, 34th Annual Technical Conference, April 26–29, 1976, Atlantic City, New Jersey, which is included as Appendix A, documents the results of combustibility tests of RTV silicone foam. In addition, the results of full-scale fire endurance tests of fire barrier penetration seals provide insights regarding the fire behavior of RTV silicone foam penetration seal assemblies. A representative fire endurance test report is included as Appendix B.